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Subterranean ant species diversity (Hymenoptera: Formicidae) in educational and biological research forest of universitas andalas, Indonesia

Henny Herwina, Rijal Satria, Yaherwandi and Yositaka Sakamaki

Abstract
The present study is a first study of the diversity of subterranean ants in Sumatra Island, Indonesia. Subterranean probes and traps were used to collect ants at Educational and Biological Research Forest (EBRF), Universitas Andalas, Sumatra, Indonesia. A total of ten species of ant [*Hypoponera truncata* (F. Smith, 1860); *Lophomyrmex bedoti* Emery, 1893; *Odontomachus minangkabau* Satria *et al*., 2015; *Odontoponera denticulata* (F. Smith, 1858); *Pheidole aristotelis* Forel, 1911; *Pheidole* sp. 1 of HH; *Pheidole* sp. 3 of HH; *Pheidole* sp. 12 of HH; *Pristomyrmex bicolor* (Emery, 1900); *Selenopsis geminata* (Fabricius, 1804)] that belonging to two subfamilies, seven genera and 330 individuals was collected. The subfamily Myrmicinae was the highest number of species which were dominated by *Lophomyrmex bedoti* and *Pheidole* sp. 1 of HH in the number of individual. These two species was found at every level of four level of soil depth. The subterranean probes were collected more species of ants than the subterranean trap with 0.92 and 0.75 in diversity indices.

Keywords: ants, research forest, subterranean probe, subterranean trap

1. Introduction
On history of earth, ants are known with its greatest success of the terrestrial insects. The ants monopolize 25% or more of the terrestrial animal biomass in tropical regions [1, 2]. This insect are play various functions in the ecosystems as predator of small invertebrates [3], mechanical decomposers [4], seed dispersers [5] and soil mixers [6]. On the other hands, not a few ant species have been known as invasive species negatively affecting native ecosystems, agriculture, public health and social infrastructure [7]. Due to its abundance in ecosystem and some species prefer the specific habitat for nesting, make the ants as the best subject for monitoring of habitat and climate changes in ecosystem [8-10].
The soil and ground litter of the world's angiosperm forests, and especially tropical forests, comprise the habitat with the highest density and species diversity of ants [11]. Ant assemblages present a great vertical stratification, with microhabitats showing strong differences in relation to species composition. Among the microhabitats, the hypogaeic ant has been poorly studied. Hypogaeic or subterranean ants live in the deeper soil layers, which make the sampling logistics and operability a difficult work [12]. Subterranean ants in particular are thought to have a significant environmental impact, although difficulties associated with collecting ants underground and examining their ecology and behavior have limited research [13]. It is widely believed that the diversity and abundance of subterranean ants may be greater than current surveys indicate [14].
Although many studies and researches have been achieved to reveal the diversity and species composition of the ground ants fauna [15], the subterranean ant usually unexplored, because the limitation of the collecting method, so the diversity of subterranean ant is poorly known. However, several new genera and species of ants have been described and collected from the soil core samples [16-19]. On the other hand, the arboreal ant is easier to study than the subterranean ant, such as the information of arboreal ants in Japan [20], and diversity of ants on *Macaranga* trees from Sumatra [21]. The present paper is the outcome of our long-term project for revealing the diversity and species composition of ants from Sumatra, and aimed to provide the information of subterranean ant.

2. Materials and Methods

Study Area: Ants were collected from Educational and Biological Research Forest (EBRF), Universitas Andalas in Indonesia (Forest edge and Inside Forest) (1º00'S, 100º30'E). The altitudes of the locations range from 250 to 450 m above sea level; temperature-range during the study was about 28 to 32ºC. Ants were sampled using subterranean traps similar to those used by [22] and modified of subterranean probes [13] on 13 of August 2017. Twenty traps and ten probes, each separated by 10 m, were implanted along each of two 200 m transect (total: 40 traps and 20 probes each) at two types of habitat (Forest and forest edge). Traps and probes were collected 24 h after placement. Comparison with arboreal ant on *Macaranga* spp. in EBRF was made (see [23] and Table 2).

Subterranean trap

The traps were capped plastic vials (8 cm high and 2 cm in diameter), with four holes each side (2 mm diameter) to allow ants access. To attract ants, sausage was wrapped with gauze or thin cloth and was hanged inside the vial. Honey was smeared on cotton and put in the bottom of vial. Traps were implanted into holes that were drilled into the soil by using crowbar at different depth (20 cm and 50 cm). A length of string or wire extending above the soil surface was attached to each trap, to facilitate trap relocation after burial.

Subterranean probe

Probe was modified to those used by Wilkie *et al*. [13], the probe was 50-cm-long plastic pipes (2 cm in diameter). The 50-cm-long plastic pipes was divided into four part of pipes (each part 12,5 cm in length) and each part was connected by Styrofoam which was fit into pipes so ants in one compartment could not move within the probe to another compartment. Four holes were made at each side (2 mm in diameter) to allow ants access. To attract ants, sausage was wrapped with gauze and was hanged in each compartment. Honey solution was smeared on cotton and put in the bottom of each compartment. Traps were implanted into holes which were drilled into the soil by using crowbar at 50 cm depth. Top and bottom of pipes were capped and a length of string or wire extending above the soil surface was attached to each probe, to facilitate trap relocation after burial.

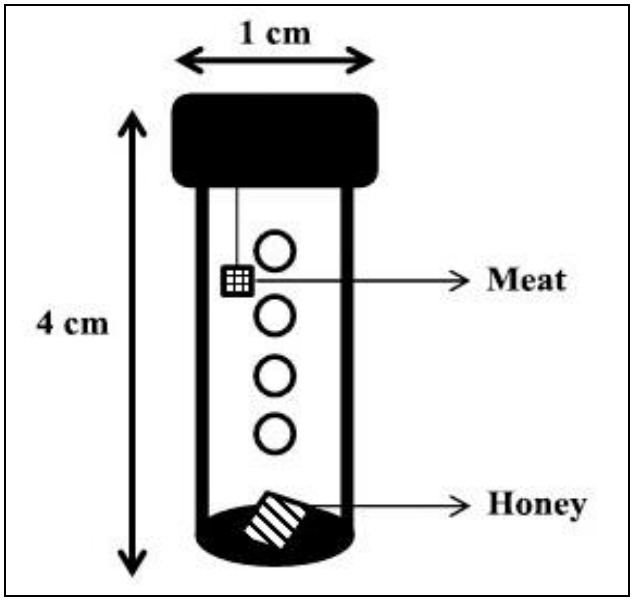

Fig 1: Design of subterranean trap for subterranean ant collection at EBRF, Universitas Andalas.

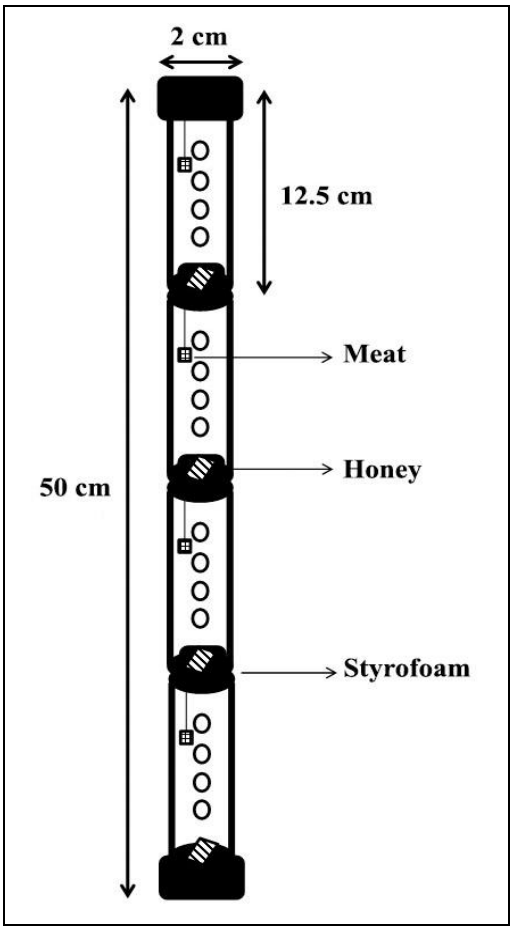

Fig 2: Design of subterranean probe for subterranean ant collection at EBRF, Universitas Andalas.

Identification: Ants were sorted to genus and morphospecies level at the Animal Taxonomy Laboratory of the Department of Biology of Universitas Andalas. Ant specimens were identified using the identification guides of [24-27]. The ant specimens were deposited in the Laboratory of Animal Taxonomy, Department of Biology, Universitas Andalas, Padang, West Sumatra, Indonesia.

Data Analyses.

The subterranean ant species diversity were calculated using Shannon-Wiener index [28] by the following equation:

$$H' = -\sum_{i=1}^{s} pi \ln pi$$

where: H' is Index of species diversity; "*pi*" is the proportion within the sample of the number of individuals of "ith" species and it is denoted as ni/N, where "ni" is the number of "ith" species and "N" is the total number of individuals.

3. Results and Discussion

A total of ten species of ant that belonging to two subfamilies, seven genera and 330 individuals were collected from two sites of EBRF Universitas Andalas by using subterranean probes and traps (Table 1). The subfamily Myrmicinae was the highest in number of species (seven species) meanwhile Formicinae was found three species (Table 1 and Fig. 2). The dominance of Myrmicinae was also reported in previous studies even though the methodology was different [7, 15, 17, 29]. The genus with the highest in the number of species was found in *Pheidole* (three species) meanwhile another genus only found one species each. The study of subterranean in

Amazonia also found that *Pheidole* was the genus with the highest in the number of species [13].

The total number of ant species collected was higher in the forest (80 %) compare to the forest edge (50%) showing the complexity of ant inside a forest compare to disturbed area such as forest edge. Shannon-Wiener diversity index of subterranean ant in the forest was 0.89 and at forest edge was lower with 0.68, meanwhile the diversity index of species combined was 1.21. The diversity indices of ants collected seems low since the total number of species richness not so high and some species dominated others such as *Lophomyrmex bedoti* and *Pheidole* sp. 1 of HH that were found very high in the number of individuals (Table 1).

The number of ant species among different depth was also various. Three or four ant species were found at 12.5, 20 (subterranean trap) and 25 cm in depth. Total number of ant species were higher at 37.5 and 50 cm in depth (six species each) (Table 1). This condition was different with subterranean ant that was reported at Amazonian [13] and Brazil [30] which found that the number of species of ants was reduced with the increase of depth.

Table 1: List of subfamily, genera, species and individual of subterranean ant species collected by using subterranean trap (20 and 50 cm in depth) and subterranean probe (12.5, 25, 37.5 and 50 cm in depth) at Educational and Biological Research Forest of Universitas Andalas, Padang, West Sumatra, Indonesia.

No	Subfamily	Species	Site		Depth (cm)				Method		
			Forest	Forest Edge	12.5	20	25	37.5	50	Probe	Trap	Total
1	Myrmicinae	*Lophomyrmex bedoti* Emery, 1893	106	73	3	57	4	80	35	97	82	179
2		*Pheidole aristotelis* Forel, 1911		37	4			3	30	37		37
3		*Pheidole* sp. 1 of HH	91	1	1	86	1	1	3	6	86	92
4		*Pheidole* sp. 3 of HH	1						1	1		1
5		*Pheidole* sp. 12 of HH	2				2			2		2
6		*Pristomyrmex bicolor* (Emery, 1900)	1					1		1		1
7		*Solenopsis geminata* (Fabricius, 1804)	1					1		1		1
8	Ponerinae	*Hypoponera truncata* (F. Smith, 1860)		4		4			4	4	4	8
9		*Odontomachus minangkabau* Satria *et al.*, 2015	6	2	5		1	2		8		8
10		*Odontoponera denticulata* (F. Smith, 1858)	1						1	1		1
Diversity Indices			0.89	0.68						0.92	0.75	1.21

Table 2: List of arboreal ant species collected at *Macaranga* spp. plants in EBRF Universitas Andalas, Padang, West Sumatra, Indonesia. 1−5 = species of *Macaranga* plants (1 = *M. depresa*, 2 = *M. gigantea*, 3 = *M. hypoleuca*, 4 = *M. javanica*, 5 = *M. tanarius*, 6 = *M. triloba*, N = Total number of individuals [23].

No	Subfamily	Species	*Macaranga* spp.						N
			1	2	3	4	5	6	
1	Dolichoderinae	*Dolichoderus (Hypoclinea) affinis* Emery, 1889				24			24
2		*Technomyrmex albipes* (F. Smith, 1861)						1	1
3	Ectatomminae	*Gnamptogenys menadensis* (Mayr, 1887)		2					2
4	Formicinae	*Anoplolepis gracilipes* (F. Smith, 1857)				5			5
5		*Paratrechina longicornis* (Latreille, 1802)		30					30
6		*Polyrhachis (Myrmhopla) abdominalis* F. Smith, 1858		2					2
7		*Polyrhachis (Myrmhopla) jerdonii* Forel, 1892	1						1
8	Myrmicinae	*Crematogaster (Decacrema) borneensis* André, 1896	571			18	449	3752	4791
9		*Crematogaster (Decacrema) decamera* Forel, 1910	198					1192	1390
10		*Crematogaster (Physocrema) yamanei* Hosoishi & Ogata, 2009	48	25	14			238,	328
11		*Crematogaster (Physocrema)* sp.		65		14		30	109
12		*Monomorium floricola* (Jerdon, 1851)				24			24
13	Ponerinae	*Diacamma holosericum* (Roger, 1860)		1					1

The specific of environmental condition probably the main reason of the differences. Three ant species (*Pheidole* sp. 12 of HH, *Prystomyrmex bicolor* and *Hypoponera truncata*) that found in this study were not found in ground dwelling ant list of EBRF (Herwina, unpublish), meaning that seven species (70 %) of ant collected was also found as ground dwelling ants of EBRF.

Comparing with arboreal ant that visited *Macaranga* spp. from six study sites of EBRF (Table 2) which found a total of 13 species of ant that belonging to nine genera and five subfamilies, no even one ant species that similar with these subterranean ant. The differences of microhabitat should be the main reason beside of specific foraging behavior and distribution of ants. However, Myrmcinae also the subfamily with the highest in the number of species, followed by Dolichoderinae, Ectatomminae and Ponerinae [23]. In *Macaranga* spp. trees, most of Myrmicinae species were genus *Crematogater* (five species) and one species of *Monomarium*. The highest number of *Crematogaster* species because of their behavior that use to stay with colony inside *Macaranga* stem and use it as a nest.

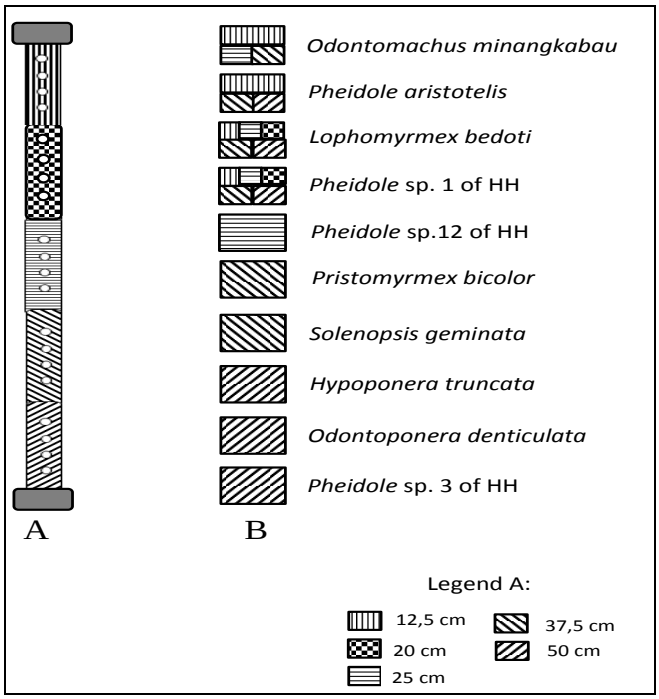

Fig 3: Ant fauna distribution collected by using subterranean trap (20 and 50 cm in depth) and subterranean probe (12.5, 25, 37.5 and 50 cm in depth). A: Schematic of probe showing location of depth. B: Ant species found in traps at different soil depth.

Figure 3 showing the distribution of each ant species among different depth and different collection methods. Six species of ants were found only in one level of depth. *Pheidole* sp. 12 of HH was found in 25 cm of depth, *Prystomyrmex bicolor* and *Solenopsis geminata* were found at 37.5 cm depth meanwhile *Hypoponera truncate*, *Odontoponera denticulate* and *Pheidole* sp. 3 of HH were found only in 50 cm depth. *Lophomyrmex bedoti* and *Pheidole* sp. 1 of HH were found at every level of depth and were appeared with the highest in the number of individual. Both of this species also were collected by both methods (subterranean trap and probe) that indicating the abundance of the species at every level of depth (Figs. 2 and 3). *Lophomyrmex bedoti* was known nesting under rocks or in the soil near the living tree. The nest structure of this species constructed with many chamber, and 10 chambers were reported in the previous study, but not found any dealate queen [29]. *Odontomachus minangkabau*, the new ant species for EBRF [31] was found only by subterranean probes at three level of depth (12.5, 25 and 37.5 cm) as well as *Pheidole aristotelis* that was collected by subterranean probe at 12.5, 37.5 and 50 cm in depth (Table 1).

Subterranean probe seems more effective by collecting seven species of ants rather than subterranean trap that only able to collect three species of ants. The diversity index of ants collected by subterranean probe was higher than by subterranean trap (0.92 and 0.75). Level of depth, size and variation of baits placement inside probes and traps possibly also affected ant collection effectivity. Subterranean traps was also collected fewer species compared to the conventional pitfall traps in Brazil [30]. The type of bait that used in subterranean trap also have influenced the result for attracted the ants, the combination of meat and honey in the present study is similar to the study of subterranean ant in Southern Brazil [12], but the collection time in that study more longer than the present study, 48 h remained the trap in the field [12]. It was make the number of collected species higher than the present study. In general, the pitfall trap for collecting the ground ant remained in the field for 48 or 72 hours, while in the present study we only placed the subterranean trap for 24 hours [32]. We recommend for the time of remained subterranean trap in the field longer than 24 h, so that the ants have enough time to rebuild theirs tunnels.

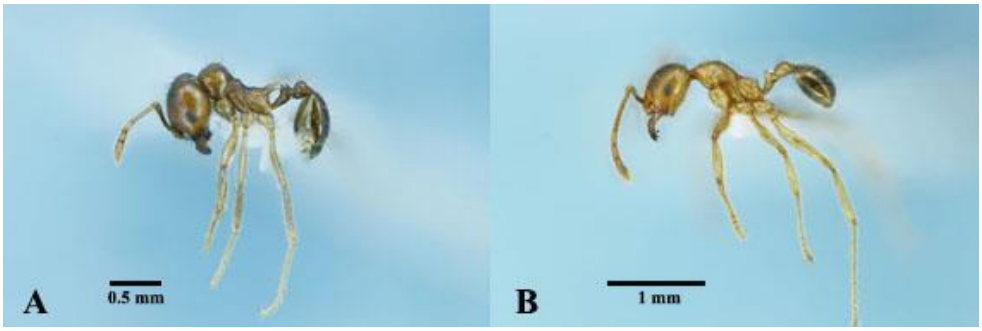

Fig 4: Two ant species that were found at every level of depth of subterranean probe and subterranean traps at EBRF Universitas Andalas. A: *Lophomyrmex bedoti*, B: *Pheidole* sp. 1 of HH

The various species of ants are live in surface of earth as well as in the subterranean and arboreal. The ants from two distinctive communities, subterranean and arboreal, were overlap little with the ground-foraging community, and they not influenced by changes in ground cover [33]. This is the first subterranean ant report from Indonesia so we could not compare with other subterranean ant in other part of Indonesia for a while. However, we understand that we need to do more sampling since our collection in this preliminary study still using 24 hours sampling period. We would like to know the effect of sampling length to the effectivity of subterranean trap and probe to the diversity of Sumatran ant in the next opportunity.

4. Conclusions

The distribution of ten ant species collected by using subterranean probe and subterranean trap at four level of soil depth at EBRF Universitas Andalas showing that all species collected were completely different from arboreal ant species collected previously on *Macaranga* spp. However, some of species were also found as ground dwelling ant of this location, suggesting that the specific distribution of subterranean ant should be consider for the arrangement of combination methods of ant collection in ant biodiversity rapid assessment.

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